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ELECTROMAGNETIC ENVIRONMENT EFFECTS SUMMARY REPORT TO THE CHIEF--ETC(U)
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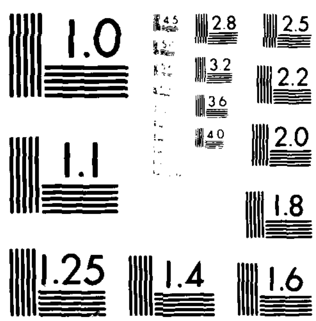

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ELECTROMAGNETIC ENVIRONMENT EFFECTS SUMMARY REPORT TO THE CHIEF OF NAVAL MATERIAL

DEPARTMENT OF THE NAVY
NAVAL MATERIAL COMMAND
TACTICAL ELECTROMAGNETIC SYSTEMS STUDY ACTION COUNCIL

30 SEPTEMBER 1977

ELECTROMAGNETIC ENVIRONMENT EFFECTS

SUMMARY REPORT

TO

THE CHIEF OF NAVAL MATERIAL

TACTICAL ELECTROMAGNETIC SYSTEMS STUDY (TESS)

ACTION COUNCIL

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EXECUTIVE SUMMARY

This report provides an assessment of the status of the state-of-technology in the electromagnetic environment (EME) relative to Navy ships and aircraft, the capabilities of Navy laboratories to address EME and the adequacy of specifications and standards relative to EME, in response to tasking by the Chief of Naval Material of 12 April 1976. Both management and technical aspects have been examined and are assessed.

This document is derived primarily from the reports of six Tactical Electromagnetic Systems Study (TESS) Action Council sponsored "technical teams", in the areas of Electromagnetic Compatibility (EMC), Electromagnetic Vulnerability (EMV), Electromagnetic Pulse (EMP), Electronic Counter-Counter-Measures (ECCM), Electromagnetic Safety (EM Safety) and Electromagnetic Power (EM Power). Major additional sources drawn upon are NAVSEA, NAVAIR and NAVELEX analyses of causes of EM deficiencies in selected systems and Fleet Commanders assessments of the operational impact of EM problems.

The various sections of this report have been designed and arranged to present a logical development of data flow. Section 1 provides introductory and background material, including the Action Council approach to its analyses and an indication of the ever-increasing impact of EM effects on fleet capabilities. In Section 2, implications of EME effects management are treated, the initiatives taken in the past OSD, SECNAV, CNO and CNM are reviewed and past and present policy iterations highlighted.

Section 3, comprising the core of the report, provides the Action Council assessment of EME state-of-technology, capabilities, and adequacy of controlling documentation as existing in the Navy. The detailed findings are set forth in summary form, in each subsection for all of the EM "disciplines".

Section 4 describes the interrelated set of documents under preparation by the Action Council; an EM Guide in the form of a Military Handbook, a comprehensive plan for applying EME effects control measures during acquisition, an in-service support plan for EME effects and a program plan for EME effects RDT&E.

Conclusions based on the assessments are presented in Section 5 in detail. In summary the conclusions state that electromagnetic environmental effects technology is generally adequate, but is insufficiently applied.

Recommendations are provided in Section 6. It is to be noted that this report does not include the detailed recommendations for effecting needed management and application of technology. Rather it provides the broad precepts which will be the base for specific implementing recommendations which will be made in the four documents which will follow this report.

1. INTRODUCTION

1.1 Purpose

The purpose of this report is to provide the Chief of Naval Material with assessments of:

a. The state-of-technology in Electromagnetic Environmental Effects (EME) relative to Navy aircraft and ship platforms. (This includes electromagnetic interference (EMI), electromagnetic compatibility (EMC), electromagnetic vulnerability (EMV) including resistance to countermeasures, and electromagnetic pulse (EMP) including high energy effects.)

b. SYSCOMs and Navy laboratory technical capabilities to calculate, measure, analyze and correct equipment, system and platform EME deficiencies, and

c. The adequacy of current Navy specifications and standards in EME, and similarly U.S. Army and U.S. Air Force progress in this area.

These assessments are in response to the tasking of subparagraphs 2.a, 2.b, and 2.c of CNM letter MAT-034/RBB:ELEX-095/RCW of 12 April 1976. Conclusions and recommendations derived from the assessments are presented for such actions as deemed appropriate.

In addition, plans for responding to two additional tasks assigned by the same letter are summarized.

1.2 Approach

Following receipt of the CNM letter of 12 April 1976, the Tactical Electromagnetic Systems Study Action Council (TESSAC) developed a plan of action, a modus operandi and a working organization to be employed in developing the responses. Representatives of the cognizant Systems Commands participated in the initial planning of the Action Council activities and also undertook preparatory actions to accomplish the tasks assigned them by paragraph 3 of the letter.

Six discipline areas of EME were identified to conduct the studies and prepare individual reports. These were EMC/EMI, EMV, EMP, ECM/ECCM, electromagnetic power, and electromagnetic safety. Teams of engineers/technologists were assembled from the Navy laboratories and centers. Under TESSAC supervision, the teams developed the six resulting Technical Team Reports which serve as the basis for this summary report.

NAVAIR, NAVSEA and NAVELEX investigated representative equipments under their cognizance to determine causes of electromagnetic environment (EME) problems. Highlights of the SYSCOM reports have been incorporated in this report. Fleet ship electromagnetic environment problems were verified at the Fleet CINC level and EME deficiencies in a Pacific Fleet Exercise, RIMPAC-77, were analyzed. Results are included herein.

1.3 Terminology

The term "electromagnetic compatibility" (EMC) is widely employed in the generic sense to encompass the various facets of electromagnetic effects. It became apparent that EMC terminology was nebulous, requiring frequent clarification when addressing generic EM areas. Accordingly, "electromagnetic environment" (EME) was adopted as a term signifying that "umbrella" encompassing all electromagnetic environment disciplines: EMC/EMI, EMV, EMP, ECM/ECCM, HERO, RADHAZ and special areas involving electro-optics and natural phenomena. As a convenient way of referring to electromagnetic environment effects, the abbreviation "E^3" has been adopted, and is used where appropriate in this report.

1.4 Contents

A determined effort has been made to preserve the principal findings and the sense of source materials, while retaining some of the substantiating detail. The nature and thrust of the underlying Technical Team Reports are encapsulated in the charts in Section 3. They and the SYSCOM reports constitute the principal basis for the text of Section 3.

1.5 Background

The effects of electromagnetic incompatibilities and vulnerabilities on fleet operations have gradually become more severe and more debilitating as the numbers and complexity of electromagnetic systems and equipments in the fleet have increased. By the late 1960's, in the Viet-Nam conflict, it became necessary to occasionally shut down certain equipments in combatant ships to prevent disruptions of or by other operating equipments, degrading operational effectiveness. Recognition of the degree of this problem and the potential combat system degradation has led to a series of OPNAV/NAVMAT management actions and studies.

The Tactical Electromagnetic Systems Study (TESS) Action Council was established in August 1975 by the CNM as a follow-up-effort to further examine and update problem statements and to propose solutions.

2. MANAGEMENT IMPLICATIONS

2.1 EME Efforts to the Present

2.1.1 Awareness of the Problem

This section provides a brief overview of EM management Navy-wide and presents management highlights derived from Technical Team Reports and SYSCOM reports prepared in response to the CNM letter of 12 April 1976.

There is a recurrent theme throughout the Technical Team Reports that management is constrained in effecting the use of available expertise and capabilities to the extent appropriate for material acquisition and operational problems. For example, Section 2.2.1 of the TESSAC Electromagnetic Compatibility Survey (Technical Team Report) states in part, "The most significant factor contributing to the lack of EMC consideration in Navy programs is not a lack of technology but a lack of application of existing technology by management." The transfer of technology from the laboratory technologists to the users, i.e., the program managers and the system/equipment development engineers, is not being accomplished when and as it should, and is one of the primary causes of present material deficiencies. This is evidenced in the majority of Technical Teams Reports by the conclusions on the inadequacies of specifications and standards and their application to acquisitions. A corollary cause is a lack of sufficiently wide spread knowledge of awareness on the part of engineers both at the headquarters and field activity level as to available EM technology and capability. A more mundane but equally important reason is the lack of a systematic storage/retrieval base for supporting management and engineering. An ancillary factor contributing to uncorrected EME deficiencies is the shortfall in reporting and identification of electromagnetic problems, either in developmental or operational phases of life cycles. This problem, too, has significant management implications.

It is clear that management, and the degree of emphasis management elects to apply to EM, play major roles in the Navy's mixed success to date in eliminating and/or avoiding EM problems.

2.1.2 Policy Declarations

There have been many iterations of Navy "policy" concerning EME or its subdisciplines originated in the past two decades. TESSAC concludes that Navy policy regarding EME is adequate. The shortcomings are in policy implementation, enforcement and assignment of resources.

2.1.3 OSD and OPNAV Initiatives

The department of Defense initiated an electromagnetic compatibility program in 1960. The program was given impetus and specific direction by the issuance of DoD Directive 3222.3 in 5 July 1967. Implementing directives were duly issued by OPNAV.

By CNO decision, the Office of Tactical Electromagnetic Coordinator (OP-03E) was established under the DCNO Fleet Operations and Readiness by OPNAV Notice 5430 of 24 November 1969. This office was upgraded and retitled to that of Director, Tactical Electromagnetic Programs (OP-093), by OPNAV Notice 5430 of 24 January 1971. OP-093 was eliminated as a "major staff office" and the functions transferred to OP-095, under the Director, Antisubmarine Warfare and Tactical Electromagnetic Programs, wherein a Tactical Electromagnetic Programs Division (OP-054) was established. Again, by OPNAV Notice 5430 of 30 May 1974, the OP-095 mission and functions were transferred to the DCNO (Surface Warfare). Nominally, the Surface Weapons Systems Division (OP-35) was responsible for tactical electromagnetic system and subsystem integration and coordination; however, by April 1975, TEMP, as such, had disappeared from OP-35 functions, leaving no identifiable sponsor in OPNAV. Most recently, by OPNAVINST 2410.31C, of 19 May 1977, the Director, Command and Control Communications (C^3) Programs, OP-094, has been assigned the overall responsibility for providing policy guidance and management direction of EMC program matters within the Department of the Navy. The Naval Communications Division (OP-941) is now the cognizant office for EMC matters in OPNAV. In this connection, it is to be noted that EMC is used in the generic sense. This parallels frequency allocation management, a necessary adjunct to EMC, also assigned OP-941.

2.1.4 NAVMAT Efforts

OPNAV Notice 5430 of 23 January 1971, which established OP-093, required the Chief of Naval Material to establish a counterpart organization. The CNM designated the Manager, REWSON Systems Project (PM-7) to be the Director, TEMP (PM-7T) within the NMC, as a collateral responsibility. NAVMATINST 5430.46 of 21 June 1971 promulgated this assignment, issued the Charter for the TEMP office, and assigned administrative support to the Commander, Naval Air Systems Command.

Executive management of TEMP was reassigned, to the Commander, Naval Electronic Systems Command, by NAVMATNOTE 5430 of 19 June 1973. The Charter for the TEMP Office, (ELEX-095), was issued as Enclosure (1) to NAVELEXINST 5430.19 of 18 April 1974, and is currently in effect.

2.2 Existing EME Effects Management

2.2.1 The CNM TEMP Office

The mission statement of the CNM Director TEMP (ELEX-095) prescribes that he shall:

". . . Exercise for the CNM centralized program management, assessment and planning for the NCM TEMP program in support of CNO requirements and policies in order to provide the Navy with balanced, compatible, effective and countermeasures resistant electromagnetic equipment. . ."

A combination of factors has militated against successful execution of the Director TEMP mission. These factors have been reviewed by the TESS Action Council, in its report of 1 March 1976, which recommended that the CNM Director TEMP (to be renamed CNM Director TECS (Tactical Electromagnetic Coordination and Support)) be placed on the headquarters staff of the CNM, and that NAVAIR, NAVSEA and NAVELEX have clearly identifiable TECS offices.

2.2.2 EME Effects Management Throughout the NMC

By Charter, regulation and established procedure, the Systems Commands have considerable semi-autonomous authority in systems and equipment acquisitions. The results of a lack of joint action in EME matters is evidenced by electromagnetic incompatibilities, vulnerabilities and other discrepancies among and between equipments and systems. This is documented and verified by supporting documentation, particularly the SYSCOM and fleet reports.

The Fleet Satellite Communications (FLTSATCOM) system provides an example of lack of EME consideration, wherein major electromagnetic interference problems were confronted when the system was placed in an operational environment. Shipboard UHF air search radars seriously interfere with FLTSATCOM terminals. Examination of the development of the system shows that "consideration" was given to EMC during design, but technical and cost constraints and a lack of adequate detailed information on shipboard EM environment resulted in the EM incompatibilities. A mandatory, consistent management-engineering emphasis on EMC was not applied.

In the Naval Material Command, considerable EM research, technology, and engineering expertise in certain disciplinary areas are located in the various laboratories and centers. These activities are under direction of the CNM or SYSCOMs according to their technological capabilities and specialties; however, the available expertise is not adequately developed nor is it applied to systems development to the extent necessary for ensuring avoidance/elimination of electromagnetic effects deficiencies. Also, prior to recent initiatives there has been no central data bank, or corporate memory, available to assist engineering and management by providing comprehensive information on EME.

Although reasonably adequate technology and capabilities are available in all EME disciplines, standards by which to apply them in procurement specifications by management are outdated. This is borne out by the assessments of Section 3 of this report. Budget limitations have had the effect of causing specifications to become inadequate, by delaying updates. Procedures for developing and updating standards require a formal and time-consuming process. The condition produced is one which seriously cripples the acquisition process. The lag of up-to-date EMC requirements being incorporated into applicable standards results in either obsolete specification requirements or intensive efforts to tailor the requirements on a case by case basis.

An additional problem associated with the currency of the specifications and standards is the long life span of many of the electronic systems. EMI problems caused delays in certification of the SPN-42 air craft carrier landing system on board USS NIMITZ. The SPN-42 was designed to what were inadequate but perceived valid EMI requirements many years ago, thus it is not surprising that there are problems in today's more complex environment.

2.3 Management Summary

There is an underlying recurrent thread throughout the reports of the E^3 Technical Teams that, although EM technology and capabilities are in general adequate for Navy needs, that which is available is not being systematically employed or applied. This can be attributed only to either a lack of priority or a lack of systematic procedures and controls, which are management attributable.

Under existing conditions, engineering managers at both headquarters and field activities are unaware of the available EME technology and capability which can be applied to the development of EM-compatible systems.

Military specifications and standards are outdated. Therefore, acquisition managers cannot rely on them as stated, to control EM design.

There is a lack of systematic storage and retrieval for an EM data base to support management and engineering to bridge the gap between technology development and system design. Lack of identification and reporting of EM problems, both in development and operational phases of life cycles, contribute to EME deficiencies. Communications between technologists, users, i.e., between design engineers and fleet operators, and managers is essential to EM planning and the direction of research and development to correct existing and future EM problems.

The issuance of directives, dictating that "EME be considered in all phases of all acquisitions" is patently not a solution. A realistic, coordinated, consistent EME effort is indicated. The effort should be carried out by a systems engineering-oriented organization, established at the CNM and SYSCOM headquarters levels, and spearheaded by an identifiable sponsor at the OPNAV level.

3. ASSESSMENT

3.1 Introduction

3.1.1 General

The tasks assigned to the TESS Action Council by the CNM are described in Section 1.1. The main thrust of the tasking is the assessment of the disciplines of EM toward reducing harmful electromagnetic effects on Naval systems and equipments. In performing the necessary assessments TESSAC grouped the disciplines of EM to reflect the orientation of technology and organizations within the Navy technical community. Thus, the grouping of EM disciplines in this section is EMC, EMV, EMP, ECCM, EM-Safety and EM-Power. Each term is defined, and a brief description of the problems and threats addressed within each discipline is provided.

The assessments of EM disciplines by TESSAC provided in this section represent the core of this report. Generalizations representative of all EM disciplines are used as much as possible to highlight the integrated aspects of the disciplines, but where capabilities, tools or deficiencies are peculiar to a single discipline, these individual cases are highlighted in the text. Supportive material is contained in Figures 3.1 through 3.3, which describe the state-of-technology, state-of-capabilities, and the state-of-specifications and standards. The foldout charts give an overview (what can be done), deficiencies (what cannot be done), and conclusions and recommendations from the six reports on EM disciplines. They are formatted to be read vertically under these column headings. The material furnished by the SYSCOMs and the fleet contain numerous examples of EMC/EMI problems covering a broad range of material. Examples of these problems used in this report are few in number--for purposes of illustrations only--and should not be construed as unique or isolated problems.

3.1.2 Description of EM Disciplines

Electromagnetic Compatibility (EMC) is the ability of electrical/electronic/electromechanical systems, subsystems and equipment to operate in an intended operational environment without suffering unacceptable performance degradation or causing the same to occur in other systems. EMC includes self-compatibility, compatibility among systems on the same platform, and multi-system/multi-platform compatibility.

Electromagnetic vulnerability (EMV) as used in the EMV Technical Team Report is the term employed to denote those problems of EMC which involve a performance degradation or an incapability to function due to undesirable reactions of an equipment to energy in the electromagnetic environment which enters the system through paths other than intended receptors. The EM energy is able to enter these items on unshielded or improperly shielded cables, through slots or holes, through non-shielded sections or the mating joints of shielded sections and numerous other apertures. Depending on the magnitude and nature of the EME, as well as the characteristics of the equipment/systems, the energy may damage solid state components, initiate electro-explosive devices (i.e., HERO), or produce spurious responses in active systems.

Electromagnetic Pulse (EMP) is an intense single-pulse transient electromagnetic wave which is usually generated when a nuclear weapon is detonated in or near the atmosphere. EMP can also be generated by nonnuclear means. Electromagnetic field strengths as great as 50,000 volts/meter can be experienced over a 2500nm diameter area from a one megaton burst at 500km altitude. Because EMP illuminates such broad areas, a system/platform does not have to be targeted to be affected. The nuclear burst can be from an attacking enemy weapon, from our own defensive weapons, from nuclear engagements of satellites, or from third parties' nuclear engagements. Exposure to EMP, especially from a burst occurring above the atmosphere, can degrade the combat effectiveness of air, land, and sea-based Navy electronic equipment if they are not hardened to the EMP environment. System degradation, even to the extent of mission or system failure, can result because of burn-out of components in the system or because of an interruption of system operation, sometimes serious enough to require reset and restart of the system.

Electronic counter-countermeasures (ECCM) is that division of EW involving actions taken to insure own forces' effective use of the electromagnetic spectrum despite the enemy's use of EW. It has two aspects--anti-ESM anti-ECM. Anti-ESM includes reducing the risk of discovery by enemy electronic detection and tracking equipment and preventing the enemy from gaining any exploitable electronic information. Anti-ECM includes the recognition and analysis of the enemy's ECM, preferably prior to employment in combat, and minimizing their effects.

EM-Safety for TESSAC purposes encompasses four areas: HERP (Hazards of Electromagnetic Radiation to Personnel), HERF (Hazards of Electromagnetic Radiation to Fuels), lightning and P-static (Triboelectricity). HERO, although included with EMV in the Technical Team Report, is part of EM-Safety. HERP consists of the direct effects of RADHAZ (radiation hazards) to personnel, which causes heating of body tissues and the indirect effects of radiation, where currents and voltages are induced in metallic structures which, when touched, cause painful burns. HERF considers the possible ignition of fuel by a spark induced by RF energy. Since the advent of metal ships, lightning has ceased being a hazard for ships and their personnel. Destruction by lightning is no longer a major threat to all-metal aircraft, although lightning effects have proved to be dangerous to flight crews and onboard personnel. Aircraft using the new composite materials are more susceptible to lightning hazards than all-metal aircraft. P-static (Precipitation-static) is the phenomenon associated with the development of high electrical potentials on the outer surface of aircraft and other fast-moving objects. P-static differs from conventional static electricity (which is also covered by EM-Safety) both in its method of production and its magnitude. P-static charges exhibit potentials of several thousand volts (up to 2 Megavolts) and they have been known to cause serious degradation of airborne equipment, rendering radar and computer systems inoperative, and are a potentially lethal personnel hazard.

EM-Power is the TESSAC term applied to the subset of EMC, EMV, EMP and EM-Safety disciplines related to the platform power system and the interface between the power system and other electrical and electronic systems and equipment. Power is essential to all fifteen mission areas of the Fleet as defined in the Naval Combat Readiness Criteria. The performance of these missions can be jeopardized by a long-term or momentary loss of power or a degradation in the quality of the electrical power brought about by electromagnetic environmental effects. For instance, a survey of 37 Pacific fleet ships on the impact of a momentary loss of power (power restored in less than 3 to 30 seconds) indicated 65 equipments were affected with recovery times ranging from minutes to hours. Mission capabilities affected included aircraft identification, detection and tracking, fire control coordination, ECM coordination, CIC data link, loss of precision landing and control, and ability to marshall aircraft. EM environmental effects can produce this type loss-of-power. The signal ground of electronic systems, which is also the secondary ground of electronic equipment power-conversion circuitry, can also be a

mechanism for causing degradation of performance of electronic systems in the electromagnetic environment.

The various EM disciplines have evolved separately due to the different sources of EM energy, causitive effects and knowledge involved in each discipline, the specialized test facilities used, and command/management assignment of organizational responsibility. These disciplines need to achieve the mutual understanding, technical collaboration, coordination and information exchange.

The description of the various disciplines reflects broad areas of technical commonality and areas of required interfaces between separate technologies. More coordination and correlation of this nature will be necessary in order for the Navy to design and integrate components within equipments, equipments within systems, and systems within or on platforms, all of which are becoming increasingly complex.

Technology and capability are assessed separately. The technical method of achieving a practical purpose, i.e., technology, may be known in various segments of the technical community but not to the Navy community needing it. Even if the existence of an acceptable technology is known, a capability in terms of tools, facilities and trained people to use the technology may not in turn be adequate to Navy needs.

3.2 State of EM Effects Technology

3.2.1 Introduction

To assess the state-of-EM Effects technology the Technical Team reports and SYSCOM reports were examined relative to: analysis, test, devices and hardware, techniques and data. The Technical Team Reports also included comparisons of Navy technology with the prevailing national state-of-the-art. Figure 3-1 summarizes the contents of the individual reports. The text summarizes the integrated assessment of the various EM disciplines.

3.2.2 Analysis Technology

Present technology permits limited basic EM analysis. It can support modeling of the natural environment (lightning and some P-static), and small, conventional systems and platforms and their individual environments, and aids in the selection of alternative concepts.

Present technology is poor or marginal in certain areas. Analysis of the effects of out-of-desired-frequency-band emissions or receptions cannot be accomplished because of lack of data or equipment and system characteristics. Ability to handle nonlinear EMI effects exists only in selected cases.

Large or complex systems or combinations of the same, for all EM disciplines, cannot be analyzed. Equipment/system arrangement on a platform or structure remains a difficulty.

EM Power analysis continues to lag ability to design. Better solutions for pulse load and harmonic current problems are needed.

Full scale mission scenario simulations to measure system effectiveness in their operational environment are not available, but are needs during concept selection, particularly for the ECCM scenarios. Analysis technology has only a limited capability to develop and utilize computer codes in prediction, and many of the existing codes are not validated.

Confidence in the adequacy of the results from complex analysis is attained only by toleration of wide engineering design margins, and by investing disproportionately in testing to verify results. Analysis and automated analysis is a cost-effective guide to testing when properly applied. Methodologies and criteria for the use of models in the various stages of the acquisition process are lacking.

3.2.3 Test Technology

Test technology can support extensive system tailoring, overcome some of the inadequacies of analysis and devise alternatives for some predictions not otherwise available. Aircraft and missile test facilities reflect fewer test technology limitations than those for ship platforms.

Among the test deficiencies reported are inadequate standardization of tests and their data. Performance verification and acceptance tests (for EMC, EMP and ECCM, in particular) are lacking.

There is also a lack of testing capacity to accommodate large or distributed systems and structures (particularly for EMP testing). Existing MILSTD filter tests requirements are not adequate to select off-the-shelf filters. Laboratory free-space measurements cannot be related to applicable specifications and standards (MIL-STD 462 and 1377). Lack of practical, realistic test requirements in specifications and standards was one of the general criticisms in the technology team reports.

The frequency range of testing technology will have to be extended outside current frequency limits as technology begins to exploit these new frequencies.

3.2.4 Hardware and Components Technology

Mitigation devices[1] are reported to be adequate for metal structures but work is needed in the area of composites. In EMP, special hardening devices are available but lack performance data and certification. Until these devices are tested and their parameters characterized, EMP protection design and analysis will remain on a case by case basis. Certain requirements are dependent upon further research in such areas as new semiconductor devices, IR/visible shielded windows and coatings, and a variety of composite materials.

3.2.5 Techniques Technology

The technology of interference reduction and other techniques such as blanking required to prevent or solve EM problems are assessed as adequate for present needs. Techniques are available for most linear and some nonlinear phenomena. The technology would be improved by more precise guidance/requirements and a selectively stronger research and analysis base.

Biological effects which cover a wide range of variables, are only imprecisely understood, and carry potentially heavy implications for personnel, some materials, costs, and conduct of operations.

The EM community needs to achieve a higher order of information exchange and cooperative engineering effort to ensure optimum selection of mitigation techniques to accommodate all EM environments. Meanwhile, programs underway to enhance EM engineering techniques should maintain their momentum.

3.2.6 Data

Lack of "adequate" data and an absence of data planning and control are pervasive problems. Existing data bases can be used to predict many EM environments but not large or complex ones such as multi-platform and interplatform environments. There is a lack of some data on specific characteristics of both USN and potential enemy systems and platforms. Most individual EM disciplines vary from marginal to poor in data quality, quantity and availability. In a large part because of data limitations, extrapolation from known to unknown situations is constrained and risky. Computer analysis, cost predictions, performance and trade-off

[1] Mitigation Devices - (shields, filters) and techniques (blanking, frequency reassignment) are used to supress the pick-up or rediation or undesired EM signals.

analyses, and many other normal engineering processes are operating at reduced efficiency. There is nothing approaching a systematic or distributed/centralized data bank or corporate memory which would allow efficient transfer of known technology to system developers and redesigners.

"More data" of itself is not the solution, nor is a sudden tightening of controls. Data support may well be one of the pacing factors in EM engineering. A number of specific needs are contained in the source materials and in Figure 3-1. A more thorough effort is required in the near future to find some feasible, economical way to serve both management and engineering information/data needs in the EM area.

3.2.7 Summary

The state-of-EM-technology is assessed as staying marginally adequate to meet the demands now placed on it in some but not all areas, yet these demands do not effectively represent either the known or formal EM requirements as contained in DoD/DoN documentation section nor those growing out of Fleet EM problems of record.

Among the prime causes of the current situation are:

- o Inadequate application of EM engineering skills and technology.
- o Some imbalance among technology functions, especially in the lagging ability of analysis as compared to test technology.
- o Weaknesses in technical support, particularly in information/data.

DISCIPLINE	OVERVIEW (WHAT WE CAN DO)	
EMC REPORT	● Analysis is good for in-band lo-gain systems, HF shipboard environments and is usable for in-band hi-gain systems and UHF simple shipboard environments ● IEMCAP antenna/cable and cable/cable coupling models are being improved and validated ● Performance degradation analysis is provided by several codes and a handbook ● SOT in test methods can support tailored operational interference controls ● Optical fibers are beginning to replace critical conventional cable runs ● Mitigation devices and interference reduction techniques are varied, adequate, up-to-date, and improving ● Signal processing techniques for EMC are beginning to be applied to complex systems ● Shielding techniques are good for simple geometries ● Bonding and grounding techniques are adequate for conventional systems ● EME definition and simulation adequate for simple intra-system problems ● Extensive data base and computer models exist for EME prediction	● Analysi and eq ● System ● No co ● Variab ● Existin ● Ability ● No pre ● Present ● Dissemi central ● Most ha
EMV REPORT	● EMV environmental levels (partially described in MIL–HDBK 235) are being updated ● IEMCAP available for internal EMV analysis ● Thin-wire models of missiles useful for susceptibility prediction ● Can partially generate hostile and friendly EME ● Can simulate performance degradation for missiles ● Lower level EME for testing specified in MIL–STD 461 ● Shielding, bonding, grounding, filtering interface techniques in use ● Fiber optics being developed as immunizing technique in critical circuits ● EMV technology generally well-developed and not lacking	● MIL-H ● Operati ● Cannot ● Analyti ● Cannot ● IEMCA ● Thin-wi ● Some p ● Need s
EMP REPORT	● Analysis can predict the EMP field for a nuclear event ● Analysis can identify problem areas, provide design assurance, and guide testing ● Full threat level certification testing can be made on smaller systems ● Subthreat level testing results can often be scaled to threat level ● Damage or upset can be determined by direct injection test techniques ● Adequate bonding, gounding, and shielding technology is available ● Special hardening techniques are available but little data available on performance ● Good Tri-service data base on components vulnerability is available ● Most needed design information is condensed to handbooks and guidelines ● Extensive Navy data bases at NSWC/WO (computer programs, guides, and reports)	● Analysis ● EMP eff ● Need bo ● Standar ● Present ● There a ● Comme ● Most ha ● Changes ● Enginee ● Present ● No data
ECCM REPORT	● Current ECCM technology in radar, RF guided weapons, electro-optical and communication systems is adequate ● Naval intelligence can provide EM threat definition and operational scenarios ● DNI is planning a common set of RDT&E documents defining ECCM threats ● Can partially generate a hostile ECM environment (primarily for radars)	● Analysis ● Complet ● ECM th trade-off
EM SAFETY REPORT	● EM-Safety can be aided by antenna pointing limitations siting and training ● Adequate surveys are performed for HERF problems ● Technology exists to model P-static phenomena ● Most currently operational aircraft are well protected against lightning ● Lightning hazards to ships/shipboard personnel essentially nonexistent	● Biologi ● No off- ● Need to ● Shipbo ● Safety t
EM POWER REPORT	● Recently developed analysis techniques are just beginning to meet needs ● Approaches are available to mitigate against loss-of-power, common-mode noise, structure currents and signal ground loops ● Testing technology is generally adequate for needs ● Increasing use is being made of switching mode power processing circuits	● Ability ● Availab ● Better s ● Analysi ● EM-Pow

DEFICIENCIES (WHAT WE CAN'T OR DON'T DO)	CONCLUSIONS AND RECO
• Analysis is very marginal for out-of-band situations because of unavailability of component and equipment characteristics • System arrangement is difficult to carry out and no methodology currently exists • No common intra-system analysis code, with all desired features, exists • Variability of equipment characteristics and coupling paths not treated statistically • Existing MIL-STD filter test requirements not adequate to select off-shelf filters • Ability to handle non-linear EMI effects exists only in selected cases • No prediction capability for grounding systems in complex systems • Present shielding techniques marginal for non-ideal cases (with apertures, etc.) • Dissemination of data, necessary for supporting computer-aided analysis, hampered by lack of central data bank • Most handbooks available are for hardware design, not inter-system EMC	• Existing technology can provide prediction of, testing for, and design safety margins have to be used • Maximum benefits will occur when technology is applied thr • Inadequate technology transfer (6.2 to user); 6.2 output must design • Continuing technology development programs may decrease d • Present emphasis on analysis program development, test tech mitigation devices/techniques is adequate • Current/planned composite material efforts will provide requi • Analysis developments now in planning will support S/S tailo • Cost-effective programs needed in: applying statistics in analy information exchange; out-of-band performance; complex sys establishment
• MIL-HDBK 235 gives only maximum EME levels; not sufficient criteria • Operational factors which vary EME are difficult to determine • Cannot directly input EME data into simulation test computer • Analytical techniques for shielding prediction are insufficiently rigorous • Cannot relate EMV/SEMI free space measurements to those of MIL-STD-462 and 1377 • IEMCAP lacks high frequency capability • Thin-wire models can't handle interior configurations • Some present shielding measurement methods do not yield true shielding values • Need shielding characterization for composite and other new materials	• Upgrade and improve MIL-HDBK 235 periodically via friendl • Develop test improvement for 1-200 MHz • Characterize shielding effectiveness of composite materials, ga adhesives • Develop IR/Visible spectrum shielded RF windows and coatin • Determine EM susceptibiltiy of charge-coupled and other new • Develop multiple signal effect techniques • Extend component susceptibility research to include lifetime/ • Optimize system level RF hardening techniques
• Analysis cannot determine the vulnerability of complex systems without testing • EMP effects on power, steering, and propulsion systems are little understood • Need better methodology for optimizing EMP protection and estimating costs • Standard methods or equipment are not adequate for life cycle hardness assurance • Present EMP simulators cannot uniformly illuminate large or distributed systems • There are no enforceable standard EMP hardness performance verification tests • Common ground and ground loop problems exist in system cabling • Most hardening devices are not certified and some are not available • Changes of system layout on parts can degrade EMP protection already engineered • Engineering characterizations of EMP protective methods and devices are inadequate • Present interaction and coupling data bases are not adequate for extrapolation • No data base exists for system failure caused by operational transient upset	• EMP protection engineering is technologically feasible for tac • SOT is adequate to predict, test for, and control EMP effects • EMP protection engineering combines analysis and testing it • Shortcomings in analysis and testing result in wide engineerin • Improvements in SOT can narrow design margins and aid cos • Maximum benefits of technology result if applied in concept • EMP hardening should be apportioned among platforms, equ • The ongoing Navy EMP technology program is basic to addre the SOT and should be continued
• Analysis is marginal for ECM versus ECCM criteria • Complete duplicate of hostile ESM/ECM systems not developed • ECM threat and ECCM requirements in threat definition/operational effectiveness/cost trade-off analysis not fully addressed	• Threat should be better defined • Develop technology and analysis techniques for more cost-eff • Establish a prioritized program to correct existing deficiencie guidelines • Designate an ECCM technology focal point • Increase emphasis on ECCM for communications systems, de vulnerability • Tendency to address overall systems performance including
• Biological interactions are unknown especially for low power level emanations • No off-axis power density computations exist • Need to evaluate requirement for personnel EM monitor • Shipboard EM radiation hazards training needed • Safety technology applications are lacking for aircraft composite materials	• Determine biological interactions for low power level emana • Biomedical research should be expanded to below 10 MHz • Need for personnel EM radiation monitor for Navy use shou • No additional HERF work required unless fuels are altered • Conduct R&D on composite materials to determine EM cha protection • Develop P-static active or passive dischargers for fixed and r • Develop a uniform grounding method to eliminate refueling • EF (electrostatic field) antenna should be tested/evaluated
• Ability to anlayze continues to lag ability to design • Available technology poorly understood and underutilized by Navy and Contractors • Better solutions for pulse load and harmonic current problems are needed • Analysis and test techniques for certain stability problems are not available • EM-Power technology often lags other technology where both are needed	• Navy relies heavily on testing since analysis has been awkwa • Newer technology requires better analytical tools to avoid g • Transfer of SOT knowledge into the Navy should be accele • Efforts to get pulse load and harmonic current solutions sho • Mitigation techniques for Navy EM-Power problems should

FIGURE 3-1 SUMMARY OF EM DISCIPLINE
STATE OF TECHNOLOGY (SOT)

CIENCIES ANT OR DON'T DO)	CONCLUSIONS AND RECOMMENDATIONS
ause of unavailability of component thodology currently exists d features, exists aths not treated statistically to select off-shelf filters selected cases plex systems s (with apertures, etc.) ter-aided analysis, hampered by lack of inter-system EMC	● Existing technology can provide prediction of, testing for, and control of EMI, although wide design safety margins have to be used ● Maximum benefits will occur when technology is applied throughout entire AP ● Inadequate technology transfer (6.2 to user); 6.2 output must be in usable form for system design ● Continuing technology development programs may decrease design margins/costs ● Present emphasis on analysis program development, test technology modernization and mitigation devices/techniques is adequate ● Current/planned composite material efforts will provide required EMC design capability ● Analysis developments now in planning will support S/S tailoring process ● Cost-effective programs needed in: applying statistics in analysis and prediction; technology information exchange; out-of-band performance; complex systems techniques; data base establishment
sufficient criteria termine mputer fficiently rigorous those of MIL-STD-462 and 1377 ield true shielding values r new materials	● Upgrade and improve MIL-HDBK 235 periodically via friendly/hostile EME inputs ● Develop test improvement for 1-200 MHz ● Characterize shielding effectiveness of composite materials, gaskets, conductive coatings and adhesives ● Develop IR/Visible spectrum shielded RF windows and coatings ● Determine EM susceptibiltiy of charge-coupled and other new micro circuit devices ● Develop multiple signal effect techniques ● Extend component susceptibility research to include lifetime/reliability effects ● Optimize system level RF hardening techniques
systems without testing are little understood n and estimating costs e cycle hardness assurance ge or distributed systems mance verification tests m cabling t available tection already engineered s and devices are inadequate uate for extrapolation nal transient upset	● EMP protection engineering is technologically feasible for tactical Navy systems ● SOT is adequate to predict, test for, and control EMP effects on electronics ● EMP protection engineering combines analysis and testing iteratively ● Shortcomings in analysis and testing result in wide engineering design margins ● Improvements in SOT can narrow design margins and aid cost/performance trade-offs ● Maximum benefits of technology result if applied in concept phase and throughout AP ● EMP hardening should be apportioned among platforms, equipments, and interconnections ● The ongoing Navy EMP technology program is basic to addressing deficiencies and advancing the SOT and should be continued
veloped /operational effectiveness/cost	● Threat should be better defined ● Develop technology and analysis techniques for more cost-effective ECCM equipment ● Establish a prioritized program to correct existing deficiencies with respect to redesign guidelines ● Designate an ECCM technology focal point ● Increase emphasis on ECCM for communications systems, data links, TACAN and IFF vulnerability ● Tendency to address overall systems performance including ECCM aspects
power level emanations r mposite materials	● Determine biological interactions for low power level emanations ● Biomedical research should be expanded to below 10 MHz ● Need for personnel EM radiation monitor for Navy use should be determined ● No additional HERF work required unless fuels are altered ● Conduct R&D on composite materials to determine EM characteristics, lightning/P-static protection ● Develop P-static active or passive dischargers for fixed and rotary wing aircraft ● Develop a uniform grounding method to eliminate refueling hazards ● EF (electrostatic field) antenna should be tested/evaluated
d by Navy and Contractors blems are needed s are not available both are needed	● Navy relies heavily on testing since analysis has been awkward or nonexistent ● Newer technology requires better analytical tools to avoid problems ● Transfer of SOT knowledge into the Navy should be accelerated ● Efforts to get pulse load and harmonic current solutions should be accelerated ● Mitigation techniques for Navy EM-Power problems should be cataloged

FIGURE 3-1 SUMMARY OF EM DISCIPLINE TECHNICAL TEAM REPORTS – STATE OF TECHNOLOGY (SOT)

3.3 EM Capabilities

3.3.1 Introduction

The SYSCOM and Navy Laboratory technical capabilities to correct EME deficiencies were assessed as tasked in paragraph 2.b of the CNM letter of 12 August 1976. Analysis capability, testing capability, availability of skilled personnel and the capability to correct fleet problems, i.e., fleet support, were assessed. The results of these findings are set forth below, highlighting strengths and deficiencies. The findings relative to capabilities are summarized in Figure 3-2. Navy capabilities to design EM-compatible platforms/systems/equipments/components exist. However, EM problems continue to proliferate in the fleet because there is no systematic methodology, including enforcement, to apply, manage and monitor these capabilities in a timely, efficient manner.

3.3.2 Analysis Capability

The capability to analyze, model and predict the electromagnetic environment exists. Most sources of electromagnetic energy, including friendly and hostile radiating sources, electromagnetic pulse, and natural sources can be analytically defined. In the ECCM specialty, the projected threat environment is difficult to pre-determine, but DNI is developing a publication to attempt to more clearly provide this information to the ECCM community. For EM power, analysis techniques are poor and continue to lag the capability to design. Recently developed analysis techniques are just beginning to approach needs.

Component susceptibility to the EM environment is well understood and can be modeled adequately. At the system/platform level, it is difficult to accurately analyze system interactions. In the EMC specialty, ship coupling mechanisms are well defined, however aircraft and missile interactions cannot be accurately specified. Analytical models are needed to determine the intra-system interactions of both ships and aircraft. The Intra-System Electromagnetic Compatibility Analysis Program (IEMCAP) is a promising tool for aircraft analysis and is being validated by.

Techniques are required to model ship's complex structures and optimal equipment arrangement on the platforms. In EMV, missile system susceptibility/vulnerability analysis is adequate. Models do exist, but development of thin-wire models and adaptation of IEMCAP should continue to upgrade the

analysis capability. Good EMP environmental models and ship coupling models are available, however, analysis alone cannot determine the EMP vulnerability of complex systems without supplemental testing. ECCM performance models are needed to evaluate system performance in terms of their mission. Except for P-static, the EM Safety phenomena are well understood. Computer models and aids exist and are used as needed.

3.3.4 Test Capability

Test and evaluation methods, instrumentation and facilities exist, at minimum levels, for partial testing of systems/subsystems in all EM disciplines. There are extensive missile and aircraft test facilities for EMC and EMV. Full EMP threat level testing capability for aircraft/missiles/small ships is currently available.

Ships can only be EMP tested to subthreat levels; vulnerability is determined by extrapolation to full threat conditions. EMP simulators and test facilities cannot accommodate large ships. Very few test procedures of instrumentation or equipment are available to perform EMI in-place testing for fleet maintenance.

EM test facilities are fair to good overall, but need upgrading. Automated analysis and test facilities are needed to reduce test time and cost. Data bases are needed to unify and transfer EM knowledge within and among Navy/Tri-Services/industry/academic communities.

3.3.4 Personnel

Expertise, in the form of personnel, exists in all EM disciplines. The number of available skilled personnel is very limited, as little as 1-3 personnel in some disciplines in some organizations, leaving little margin beyond current workloads.

If the EM community were utilized properly by PM/AM's, including greater use of EM-Programs, during system life cycles, present EM personnel resources would be strained heavily. To augment and complement existing Navy EM capabilities, new personnel must be trained and/or experienced personnel drawn from the other sources.

Outside the EM engineering community, training is needed to educate in the broad range of skills--from maintenance personnel through managers--in EM matters to increase their knowledge and awareness of potential

problems, their symptoms and sources of technical assistance. That this training is essential is illustrated by the EMI problems occurring on CG-26 class ships and the USS NIMITZ, and which could have been avoided or limited by knowledge of standard EM engineering practices. On the CG-26 class interference to the HF communications system, including Link 11, was due to the interaction of multiple radio emitters with the ship's hull, superstructure and especially appendages to the hull, such as metallic ladders and armored cables. Had EM technology been utilized, the preferred EM practice of fabricating top-side appendages from non-metallic materials could have been incorporated into topside ship design. Aboard NIMITZ there is indication that the arcing problem with the AN/SPS-37/43 is related to installation and/or maintenance problems.

The ECCM source document reports that approximately 45% of ECCM related system problems experienced to date are purported to be a consequence of the lack of proper training of personnel in the ECCM discipline. TESSAC judges that this condition exists, to varying degrees, in other EM areas as well.

3.3.5 Fleet Support

Capabilities, resources, facilities and skilled personnel exist although in austere numbers in places. These capabilities are assessed as inadequate to effectively control EM problems in the fleet. The methodology and machinery for insuring that EMC is implemented into the full life cycle from system design and through deployment are also not available. There is little utilized capability for interaction among the SYSCOMs, the EM technical community and the fleet to correct EM problems.

For ships, the SEMCIP program provides teams to perform ship surveys on a planned basis and when individual problem arise. SEMCIP has a systematic approach to their work, its major constraints are in the availability of skilled personnel and budgetary resources.

In the aircraft community, there is no dedicated team or reporting procedure to service their types of EM problems and ensure resolution. Such teams should be established and utilized.

Force level, multiship/air EME are seldom reported and even less often measured. TESSAC in conjunction with NAVSEA has sponsored efforts to look beyond present single-ship EME in an attempt to measure and document more complex EM environments. The two efforts to date have been conducted by

SEMCIP personnel under the direction of COMTHIRDFLT in exercise RIMPAC 77 and COMSECONDFLT in MSR 77. Initial results have indicated that the magnitude of intrasystem/intraship EMC problems have not been understood and require increased attention.

To provide a timely response to the fleet, an EM communications/reporting link should be established among the fleet, SYSCOMs and the laboratories using existing lines of communication if possible. The existing reporting systems indicate problems by system or equipment and were designated for different purposes. It is essential that a reporting system which can readily accommodate EM problems in terms suitable for diagnosis and corrective action be set up. Feedback, analysis and utilization of fleet problem experience in improving acquisition should also be provided for. An existing system, such as AWCAP/SMSDCAP, possibly could be adapted for this purpose.

3.3.6 Summary

In summary, Navy EM capabilities do exist, with deficiencies as noted above. To optimize the usage of these capabilities, EM disciplines must impact at the conceptual and early design phases of systems/platforms and follow through the process as required. Fleet reporting procedures which more correctly identify EM problems must be investigated. Personnel should be trained within the EM community and outside it to recognize both the consequences of ignoring EM and the actual EM problems when they occur. When its resources of instrumentation, procedures, and people have been strengthened and applied properly, the Navy will gradually become able to operate its systems in the fleet environment with minimal EM environmental effects and their resulting degradation in operational performance.

DISCIPLINE	OVERVIEW (WHAT WE CAN DO)
EMC REPORT	● EMC design capability is usable for current needs: "scientific" at component level; "artistic" at system level ● SEMCIP program provides successful Fleet problem support, shipboard EMC and maintenance procedure training ● Analytical capabilities in coupling are good for simple intrasystem cases (IEMCAP validation on aircraft just beginning); performance prediction capability is being developed and has proven cost effective ● Testing facilities are widespread and provide adequate support except for ship platforms ● Qualified personnel are available in limited numbers to support EM programs ● Existing frequency management capabilities are adequate for today's needs ● Capability exists to support specification tailoring
EMV REPORT	● Capability to produce HERO-free weapons and EM problem-free GSE is complete ● SEMCIP improved EM posture of every ship investigated ● High intensity EMEs can be generated at some Navy facilities ● Most EMEs can be fairly well defined for vulnerability ● Personnel and equipment are available to conduct needed EMV testing and analysis ● Expertise exists to impart EMV technology to system design efforts, to provide fixes, and to support EM programs
EMP REPORT	● The Navy capability to analyze components/circuits is current with SOT ● The Navy shares ability to analyze aircraft/missiles with other services ● Computer codes are available for survivability/vulnerability analysis ● The Navy can use SOT to predict isolated cable/antenna coupling interactions ● Aircraft fly-by test capability is unique to Navy (EMPRESS, EMPSAC) ● Aircraft and missiles can be tested fo full threat level ● Small and medium ships can be tested to subthreat level ● Navy specialists are available to support EM programs
ECCM REPORT	● Navy Intelligence (DNI) has a partial capability to provide EW threat definition and operational scenarios ● Navy has the capability to design ECCM system features and analyze/calculate individual system ECCM performance and costs ● Navy has the capability to measure/test system ECCM performance through the labs, OPTEVFOR/OTD and TAC D&E ● Navy has the capability to correct system and platform ECCM deficiencies
EM SAFETY REPORT	● Safety capabilities are adequate ● Current capability can handle all HERF-related problems ● Aircraft P-static problems can be dealt with in field activities and EM programs ● Non-ionizing radiation effects research capability exists in Gov't/industry/academia ● Navy/industry conducting studies (analysis & tests) on lightning problems ● Shipboard EM safety problems handled through Navy survey teams
EM POWER REPORT	● Navy capability to test is good but becoming less cost-effective in some areas ● Capability exists to solve classical EM-Power problems ● Power processing circuits in Navy systems are rapidly increasing in complexity ● Several Navy facilities are upgrading SOT knowledge with ad hoc short courses

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DEFICIENCIES (WHAT WE CAN'T OR DON'T DO)	CONCLUSIONS AND RECOMM
• Many available analysis codes do not represent a capability because a lack of assessment prevents users from making optimum choices • System performance determination capabilities inadequate for engineering design • No support program equivalent to SEMCIP exists for aircraft • Problem reporting is difficult; problem identification is even harder • Future frequency management will require more scientific and analytical techniques • Spectrum signatures and characteristics for recent equipment are scattered throughout Navy or not available • Very limited capability to perform tailoring of standards and specifications • Large platform test capabilities are nonexistent • Present cost of performing measurements is quite high • Poor coordination between EMC and EW personnel prevents EW's use of EMC analytic and design capabilities	• Navy EMC capabilities are generally not adequately utilized b • More use of EMCABs early in the AP will better utilize EMC c • A technology exchange program can overcome compartmenta • Continue present efforts to reduce analysis codes to a capabili • Reduced cost of measurements could come via combining and standards and from automated test facilities in development • Develop frequency management capability, incorporating new • Developing the short courses, tailored to users, and presenting and help make PM/AM aware of available EMC capabilities an • Participation of EW personnel in EMCABs will help communi the burden of attaining EMC
• Existing design expertise not being applied in timely manner in either design or rework/overhaul areas • Need readily available, low cost testing techniques • Standard tests for composite material technology not yet available	• Validate IEMCAP for ships • Develop standard tests in composite material technology area • Support ongoing efforts to find cost-effective test techniques
• SOT inadequate for analysis of shipboard antenna and cable EMP interactions • Large ships cannot be tested at EMPRESS facility • Subthreat illumination levels for hardened ships is marginal for testing • Navy is not equipped for automated acquisition of EMP test data • Ability to verify hardness in factory or in place is minimal	• EMP capabilities in the Navy and elsewhere combine to prov • Adequate consideration of EMP is necessary in early and sub • An EMP simulation for large ships and higher illumination le • For efficiency, automated data collection for testing should • Life cycle hardness assurance methodology should be develo
• Present EW threat definition is not sufficiently detailed, future oriented, nor mission related • Analyses capabilities are inadequate for systems and mission • There is a lack of data bases or Navy system characteristics for ECCM • Navy EW assets have generally not been well utilized in support of total weapons system ECCM • Lack of EO CCM test coordination with OTD USN/USMC EO efforts • Lack of capability to perform EO CCM testing in a marine environment • Shortfalls in ECCM training	• Develop an EW threat definition by joint technical and inte • Ensure financial support is available and appropriate for EC • Develop an automated data base for ECCM systems • Increase ECCM testing, particularly of communication syst • Emphasize ECCM training requirements in system developm
• Safety capabilities not effectively utilized • Comprehensive NAVMAT/SYSCOM directives on safety are not complete • Insufficient knowledge exists to resolve problems posed by advanced materials/equipments • P-static phenomena for rotary wing aircraft not adequately understood • Little product-oriented research is being conducted on phenomena for EM safety	• Implement approved Navy training program for SEMCIP • Include HERF in a radiation hazards educational program • Continue development in advanced materials, phenomena,
• Navy EM-Power capability is sparse • Navy capability to analyze is poor • Testing is rarely supported by analysis • Poor knowledge of SOT by Navy and Contractors hampers capability to solve problems • Data bases are inadequate for system integration and other needs	• Navy capability is on par with other DoD but greatly lags • Seven of ten Navy facilities capability is limited to 1–3 p • Only one facility is trying to regain its capability • Navy EM-Power capability should be upgraded and sustai • Automated techniques should be developed for cost-effec

FIGURE 3-2 SUMMARY OF EM DISCIPLINE TECHNICAL

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ES DON'T DO)	CONCLUSIONS AND RECOMMENDATIONS
because a lack of assessment for engineering design ft harder and analytical techniques nt are scattered throughout Navy d specifications ts EW's use of EMC analytic and	● Navy EMC capabilities are generally not adequately utilized by management ● More use of EMCABs early in the AP will better utilize EMC capabilities ● A technology exchange program can overcome compartmentalization of technology ● Continue present efforts to reduce analysis codes to a capability ● Reduced cost of measurements could come via combining and simplifying appropriate standards and from automated test facilities in development ● Develop frequency management capability, incorporating newest technology ● Developing the short courses, tailored to users, and presenting them on-site will share technology and help make PM/AM aware of available EMC capabilities and timely need for same ● Participation of EW personnel in EMCABs will help communications/electronics and EW share the burden of attaining EMC
r in either design or available	● Validate IEMCAP for ships ● Develop standard tests in composite material technology area ● Support ongoing efforts to find cost-effective test techniques
EMP interactions for testing t data	● EMP capabilities in the Navy and elsewhere combine to provide a strong technology capability ● Adequate consideration of EMP is necessary in early and subsequent stages of the AP ● An EMP simulation for large ships and higher illumination levels should be built ● For efficiency, automated data collection for testing should be developed ● Life cycle hardness assurance methodology should be developed
ture oriented, nor mission related n for ECCM pport of total weapons system EO efforts environment	● Develop an EW threat definition by joint technical and intelligence input ● Ensure financial support is available and appropriate for ECCM test equipment ● Develop an automated data base for ECCM systems ● Increase ECCM testing, particularly of communication systems, data links, TACAN, and IFF ● Emphasize ECCM training requirements in system development
e not complete y advanced materials/equipments y understood nomena for EM safety	● Implement approved Navy training program for SEMCIP ● Include HERF in a radiation hazards educational program ● Continue development in advanced materials, phenomena, and equipment
capability to solve problems r needs	● Navy capability is on par with other DoD but greatly lags NASA, SOT, and Navy needs ● Seven of ten Navy facilities capability is limited to 1–3 people ● Only one facility is trying to regain its capability ● Navy EM-Power capability should be upgraded and sustained at level needed ● Automated techniques should be developed for cost-effective testing and data bases

FIGURE 3-2 SUMMARY OF EM DISCIPLINE TECHNICAL TEAM REPORTS – EM CAPABILITIES

3.4 State of EM Standards and Specifications

3.4.1 Introduction

This section describes the adequacy of current general specifications and standards and related documents in EME effects. The emphasis is on Navy status with reference to U.S. Army and U.S. Air Force status only where they are different and significant in terms of the Navy. No attempt was made to review individual system/equipment procurement specifications although an excellent review is to be found in references, and are set forth tabularly in Figure 3-3.

3.4.2 Definitions

The Armed Service Procurement Regulation (ASPR) states that items to be procured shall be described by reference to applicable specifications or by a description containing the necessary requirements. A specification is a document used primarily for procurement which clearly and accurately describes the essential technical requirements for the procured item and the procedures to determine that the requirements are met. A standard is a document created primarily to serve the needs of designers and to control variety. In equipment specifications, standards are referenced to prescribe those design and testing requirements which are essential to interchangeability, compatibility, reliability, and maintainability. Military handbooks are documents containing reference data or guidance for use in design, engineering, production, procurement, and supply management operations. They are used for the preparation of specifications and standards. Recent (21 May 1976) changes in the Armed Service Procurement Regulation (ASPR) require referenced specifications and standards to be tailored in their application, thus formalizing an existing practice. ASPR defines tailoring as the exclusion of those sections, paragraphs or sentences of individual specifications and standards not required for a specific procurement. Tailoring as used in this report is a somewhat broader concept in that it includes adding and changing specification content as well as deletion of content.

Specifications and standards in the text and in the tables are used in this report to mean either general specifications or standards or both, or related documents such as handbooks and directives that serve similar purposes.

3.4.3 Criteria

The criteria used in this report for determining the adequacy of specifications and standards and related documents are: Do they exist? Do they

specify both the technical requirements and the procedures to determine the requirements are met? Are they in consonance with the expected EME and operational requirements? Are they compatible with joint specifications and standards? Are they compatible with the technology and engineering practices expected to be used? Are they compatible with data needs? Are they reasonably easy to tailor? And, when the individual specifications and standards are collectively viewed, do they cost-effectively state the Navy technical requirements for systems/platforms that meet operational requirements in a *real-life* EME *and* cost-effectively state the procedures to determine the technical requirements are met?

3.4.4 Findings

It was commonly acknowledged in all Technical Team and SYSCOM reports that most EM specifications and standards are outdated and need revision. A time lag between the issuance of specifications and standards and new technology exists which is the source of many problems.

Equipments such as the AN/SPN-41 aircraft approach control system and AN/SPN-42 aircraft carrier landing system were fleet problems because radiated susceptibility requirements were not included in the EM specifications. Other fleet problems have occurred because requirements in existing specifications and standards were waived, deviations authorized, or the EM requirements ignored. Numerous examples can be cited in current or recent aircraft procurement, such as the S-3A, F-14A and the EA-6B. EM specifications and standards have also been cited as being too lax, such as the radiated E-field susceptibility limit (RS03) of one volt/meter in MIL-STD 461 when equipment is used above decks and too stringent such as the conducted power line conducted emission limit (CE01) when this limit is applied to high power equipment.

Tailoring of specifications and standards for each individual application is initially an appealing solution to many of the above problems, such as specifications and standards lagging the technology and being too lax or too stringent for a given purpose; however, successful tailoring requires highly experienced personnel, of which the Navy has a limited number in the EM field, or personnel with lesser experience using adequate tailoring guidelines. These guidelines are mostly non-existent. The problems caused by uninformed tailoring can be expected to be as severe or worse than those caused by uninformed waivers

and deviations. For example, the power line conducted susceptibility test (CS01), of MIL-STD 461 is often tailored out because the person performing the tailoring is unaware that it can detect a common power supply design fault not uncovered by any other test that the equipment is normally subjected to in the acquisition process.

The non-existence of specifications and standards is another problem. There are no specifications and standards for the EM disciplines of EMV, EMP, or ECCM. No Navy specifications and standards provide requirements or assurance procedures for P-static or lightning. There is no specification or standard harmonizing the grounding system to minimize EM from the EME-related to EMC, EMV, EMP, EM Safety and EM Power and their requirements. There is no equivalent of MIL-E-6051 for ships that specifies general EMC. However, there are documents that can be used as data sources for tailoring existing specifications and standards for some of these purposes. These include MIL-HNDBK 235, which defines free space EME in the vicinity of friendly and hostile platforms; MIL-HNDBK 237, which gives guidelines for management and control of EMC; and a proposed SAE standard that defines standard testing wave forms for lightning.

Even where specifications and standards exist, joint specifications and standards are often incompatible. Overlaying the documents controlling a common interface may indicate negative design margins. The requirements in the joint specifications give no assurance that the equipments can operate with each other. Accommodation of contradictory EMC and ECM needs is a similar problem. Along with many other EMC worries, requirements and testing for both friendly and hostile ECM must be defined. The EM environment can be, and occasionally has been, described in requirements, analyses and design for conventional engineering purposes for platform EME (EMV/EMC, etc.) interactions--e.g., radars and communications operating simultaneously; however, our analysis capability, as discussed earlier, is weak. Unfortunately, EW equipment operations, both friendly and hostile are seldom addressed or defined in contractual documents. Own forces ECM for example, poses a special problem. One of its purposes is to modify the EME in the vicinity of the platform. Own forces equipment must operate in the environment. Additionally, hostile ECM can be expected to be specifically aimed at degrading system, platform or force EM capabilities by creating an incompatible environment. Definition of our ECM is possible, but definition of hostile ECM will be a foreign intelligence-based estimate. Both must be considered for effective naval operations.

The use of specifications and standards for assuring technical requirements are met is generally poor. Standards contain no quality assurance provisions. They either state standard limits, such as MIL-STD 461, or standard test procedures, such as MIL-STD 462. Assuring technical requirements are met is left to the generalized detailed specifications. This is as it is supposed to be. However, general assurance provisions are omitted from general specification placing the total burden on the detailed specification. For example, the general electronic equipment specification for avionics, MIL-E-5400, references MIL-STD 704, the aircraft electrical power standard for the technical requirements for electrical power. MIL-STD 704 contains no assurance provisions and MIL-E-5400 provides none except the notation it is to be provided in the detailed specification. The full assurance burden falls on the author of the detailed specification, an inefficient and potentially risky approach.

ASPR states data requirements are to be controlled by the contract, not specifications and standards. However, the procedures and formats for data and classes of data can be controlled by standards. EM engineering is less effective than it could be because of the fact that data needed in the analysis and design processes is unavailable or unuseable. In some cases, such as EMP effects on ships, the data is sparse and difficult to obtain. In other cases, such as MIL-STD 461 test data, the amount of data collected is extensive but of little use in system integration because of the accept-not accept format of some of the data and the lack of standard acquisition, storage, and retrieval of the data. The creation of standards to control EM data formats can be used to greatly improve the data acquisition, storage, and retrieval situation and make the data more useful.

3.4.5 Summary

Specifications and standards are one of the most important tools available for controlling EME effects in the fleet and have made possible many of the successful EM equipments and systems now being employed. It is because of this importance that any shortcomings in specifications and standards are of direct and immediate interest. By the very nature of their scope and content, specifications and standards tend to lag Service requirements and the state of technology by as much as two or three years. Effective control of EME effects requires shortening this time as much as possible while concurrently using tailoring as a method of overcoming whatever shortcomings there may be in the existing specifications and standards.

It was commonly acknowledged in all the Technical Team and SYSCOM reports that many specifications and standards are outdated and in need of revision, are non-existent in some cases, and need uniform tailoring guidelines. The vital role of specifications and standards in controlling EME demands that this situation be improved.

DISCIPLINE	OVERVIEW (WHAT WE CAN DO)	
EMC REPORT	● S/S properly utilized can avoid later expensive modifications to achieve EMC ● Limited provision now exists in S/S for (1) management guidance in concept development, (2) integration/installation guidance, (3) frequency management guidance for radar systems, and (4) requirements for documentation of test and analysis results ● Current S/S can support an EMI program, but only via experienced engineering personnel ● Tailoring S/S is a viable compromise between rigid standards and costly "hand-crafted" systems and avoids the need for a large engineering effort ● Current standards are generally usable as starting points for development of revised or "tailorable" standards ● Current technology can support tailored specifications	● Ineffec… require… ● Lag of S… ● Existin… ● S/S on … need sp… ● S/S do … wavefo… aging a… ● Newer … proces… ● Present … tailorab…
EMV REPORT	● MIL-HDBK 235 undergoing revision and update ● HERO/GSE have upgraded specs/stds which are adequate ● When modified, EMC specs/stds may be used for EMV ● Properly tailored, existing specs/stds can adequately define EMV performance	● Very fe… ● MIL-ST… ● Existin… ● MIL-ST…
EMP REPORT	● Two S/S approaches are feasible – Critical system approach (ad hoc S/S) – Mil-spec approach (tailored general S/S) ● A few existing EME S/S reinforce EMP survivability to some extent ● Current efforts to develop handbooks, data bases, design guidelines and S/S are supportive of a consistent approach	● S/S are … ● The dat… systems…
ECCM REPORT	● ECCM requirements which are integral to overall system specifications and standards can be developed	● There a… proced… ● There a… ● Intellig… ESM/E…
EM SAFETY REPORT	● BUMED publishes EM radiation exposure limits which SYSCOMs implement ● Revision of RADHAZ standards in the microwave region is being investigated ● HERF is adequately documented ● NAVORD OD-44811 Vol. I and OD-10773 adequately specify static electricity requirements ● Current lightning specs are utilized only for new aircraft	● Certain… ● No NA… ● No co… ● Some … ● Wave …
EM POWER REPORT	● S/S controlling EM-Power vary individually from adequate to very poor. They are generally inadequate in relationship to each other and to the emerging technology being used in Navy systems	● Existi… ● Existi… ● S/S ig… ● Ship S… ● S/S te…

DEFICIENCIES (WHAT WE CAN'T DO OR DON'T DO)	CONCLUSIONS AND RECOMMEND
• Ineffective implementation and excessive waiving of S/S yields *unreliable operation* and requires costly fix-ups • Lag of S/S behind technology is endemic to DoD standardization system • Existing S/S are inadequate in needed out-of-band component performance • *S/S on filter testing, shielded enclosures, lightning effects, gounding and spectrum* signatures need specific revisions • S/S do not cover large platform tests, hull penetration, *unified* grounding, lightning test waveforms, cable pick-up, shielding gaskets, conduit, arrangement and decoupling and gasket aging and corrosion • Newer technologies of composites, fiber optics, phased arrays, *spread* spectrum and micro-processors not considered in S/S • Present standards are written in a general way which requires *tailoring but are not* readily tailorable, and tailoring guidelines/approach does not exist	• A revised/unified standardization process can reduce lag between S/S • Concise waiver requirements will reduce engineering costs • A management guidance handbook covering early acquisition phases • Computer information retrieval can provide interrelationships for sta • Standards evolvement should be oriented toward system problem sol mitigation equipment • Modify and use some DNA, IEEE and SAE standards to cover areas MIL-STDS • Standardization of *installation* and *integration practices* requires Nav payoff is optimized platform configurations • Tailoring can be achieved by doing systems engineering using current techniques • Development of concise tailoring guidelines will make tailoring proce
• Very few system/platform specs/stds provide EMV requirements • MIL-STD-461 *limits* are *40dB* too low for critical EMV environments • Existing specs/stds overlap, conflict, and are obsolete in some areas • MIL-STD-1377 and 285 data can differ by 10-20 dB for shielding effectiveness	• Need adequate set of specs/stds which address EME and T&E requir of application • Establish effective interface between specs/stds efforts and technolo • During S/S revision, emphasis should be on integrated EM considera • Extend MIL-STD-1377 techniques for shielding effectiveness to bel
• *S/S are very meager or nonexistent for all aspects of EMP protection* • The data base for writing S/S for *hardening* ships is meager because few ships or ship systems have been hardened	• The mil-spec approach is better suited and recommended for tactic • A concentrated effort is required throughout NAVMAT to develop requirements at the equipment, subsystem, system, and platform le • *Experience indicates specifying performance* at the component level fabrication and design procedures at the systems level are the best • Considerable information is available on EMP hardening and should • S/S for EMP protection are needed at the system, subsystem, and co
• There are no specifications or standards prescribing ECCM susceptibility tests and test procedures • There are no guidelines for specifying an ECM environment • Intelligence exploitation limitations will preclude a wholly *accurate* definition of an ESM/ECCM hostile environment	• Develop specifications and standards for ECCM susceptibility tests • Establish guidelines for ECM environment • Update MIL-HDBK 235 to define the EME environment for ECCM
• Certain SYSCOM *instructions are not* consistent with latest BUMED Instructions • No NAVSEA or NAVAIR *lightning/P-static* standards exist • No composite *material standards exist* • Some Navy safety specs are outdated • Wave shape utilized for tests called out in MIL-B-5087B is difficult to produce in Labs	• Effort should be expended to fill the gaps and revise safety S/S • Each SYSCOM should be directed to write safety guidance and im • Future safety criteria should be based on current scientific data an • Navy should provide S/S to assist manufacturer and Board of Insp • New *MIL-B-5087B waveform should be developed* • Impose MIL-E-6051D on aircraft designers/manufacturers for EM • Develop S/S for safety operating requirements and test instrument
• Existing conjoint S/S are mismatched on the common interface they control • *Existing S/S and the technology being used are incompatible* • S/S ignore signal ground or encourage practices that increase E^3 sensitivity • Ship S/S don't require operation through transients occurring several times a day • S/S test requirements not adequate to demonstrate performance in expected EME	• Existing general S/S are inadequate to assure operation in expect • Consistent S/S *tailoring* procedures are needed while S/S are imp • Better management methods are needed to get SOT knowledge in

FIGURE 3-3 SUMMARY OF EM DISCIPLINE TEC
EM SPECIFICATIONS AND STANDA

NCIES DO OR DON'T DO)	CONCLUSIONS AND RECOMMENDATIONS
g of S/S yields unreliable operation and standa dization system d component performance g effects, gounding and spectrum signatures ation, unified grounding, lightning test uit, arrangement and decoupling and gasket phased arrays, spread spectrum and micro- hich requires tailoring but are not readily s not exist	• A revised/unified standardization process can reduce lag between S/S and technology • Concise waiver requirements will reduce engineering costs • A management guidance handbook covering early acquisition phases is required • Computer information retrieval can provide interrelationships for standards • Standards evolvement should be oriented toward system problem solutions vice EMI mitigation equipment • Modify and use some DNA, IEEE and SAE standards to cover areas now ignored by MIL-STDS • Standardization of installation and integration practices requires Navy-wide cooperation, but payoff is optimized platform configurations • Tailoring can be achieved by doing systems engineering using current EMC tools and techniques • Development of concise tailoring guidelines will make tailoring process cost effective
V requirements EMV environments olete in some areas dB for shielding effectiveness	• Need adequate set of specs/stds which address EME and T&E requirements for all levels of application • Establish effective interface between specs/stds efforts and technology effort • During S/S revision, emphasis should be on integrated EM considerations • Extend MIL-STD-1377 techniques for shielding effectiveness to below 1GHz
s of EMP protection s is meager because few ships or ship	• The mil-spec approach is better suited and recommended for tactical systems • A concentrated effort is required throughout NAVMAT to develop common hardening requirements at the equipment, subsystem, system, and platform levels • Experience indicates specifying performance at the component level and specifying fabrication and design procedures at the systems level are the best approaches • Considerable information is available on EMP hardening and should go into S/S • S/S for EMP protection are needed at the system, subsystem, and component levels
ing ECCM susceptibility tests and test vironment a wholly accurate definition of an	• Develop specifications and standards for ECCM susceptibility tests and test procedures • Establish guidelines for ECM environment • Update MIL-HDBK 235 to define the EME environment for ECCM system design
with latest BUMED Instructions dards exist -5087B is difficult to produce in Labs	• Effort should be expended to fill the gaps and revise safety S/S • Each SYSCOM should be directed to write safety guidance and implementing Instructions • Future safety criteria should be based on current scientific data and updated regularly • Navy should provide S/S to assist manufacturer and Board of Inspection and Survey • New MIL-B-5087B waveform should be developed • Impose MIL-E-6051D on aircraft designers/manufacturers for EM safety • Develop S/S for safety operating requirements and test instrumentation
mon interface they control compatible at increase E^3 sensitivity ts occurring several times a day e performance in expected EME	• Existing general S/S are inadequate to assure operation in expected EME • Consistent S/S tailoring procedures are needed while S/S are improved • Better management methods are needed to get SOT knowledge into S/S

FIGURE 3-3 SUMMARY OF EM DISCIPLINE TECHNICAL TEAM REPORTS – EM SPECIFICATIONS AND STANDARDS (S/S)

4. PROJECTED DOCUMENTATION

4.1 Background

In order to determine the optimal manner in which to make responses to the CNM tasking of 12 April 1976 (Section 1.1), a workshop was held in which highly qualified Electromagnetic Environment Effects EME management and engineering personnel from OPNAV, NAVMAT, three SYSCOMs and the laboratories participated. TESSAC's approach to the desired documents is based upon the workshop recommendations. Five interrelated documents are projected (Figure 4-1). Document writing teams have been identified and a "Master Document Schedule" was developed (Figure 4-2). This report constitutes TESSAC's summarized response to the CNM Tasks assigned in paragraphs 2.a, 2.b, and 2.c of CNM's letter. The remaining four documents will be:

Navy EME Guide
Plan for Ensuring EME Controls in Acquisitions
In-Service Support Plan for EME Effects
Program Plan for EME Effects RDT&E

4.2 Navy EME Guide

This guide, projected as a military handbook, "Navy-Only" its initial issue, will contain primarily management guidance for those who are required to address the effects of the electromagnetic environment on or from a platform, system or equipment throughout its life cycle. It will describe process to be followed, pertinent other military and government documents. management, contracting, planning, technical considerations and related disciplines and programs. The basic document will be management oriented, with specific guidance tailored for individual groups (e.g., managers, engineers, users) provided. It is intended that this guide will be a continuing, evolving document with periodic reviews and updates as necessary. Although the guide was not assigned as a specific task by the CNM, it is believed by TESSAC to be very necessary. This guide is expected to make a valuable contribution to fleet EM effectiveness. A draft copy is scheduled for review by early November 1977 and final preparation for introduction into the MILHANDBOOK approval cycle is anticipated in December 1977.

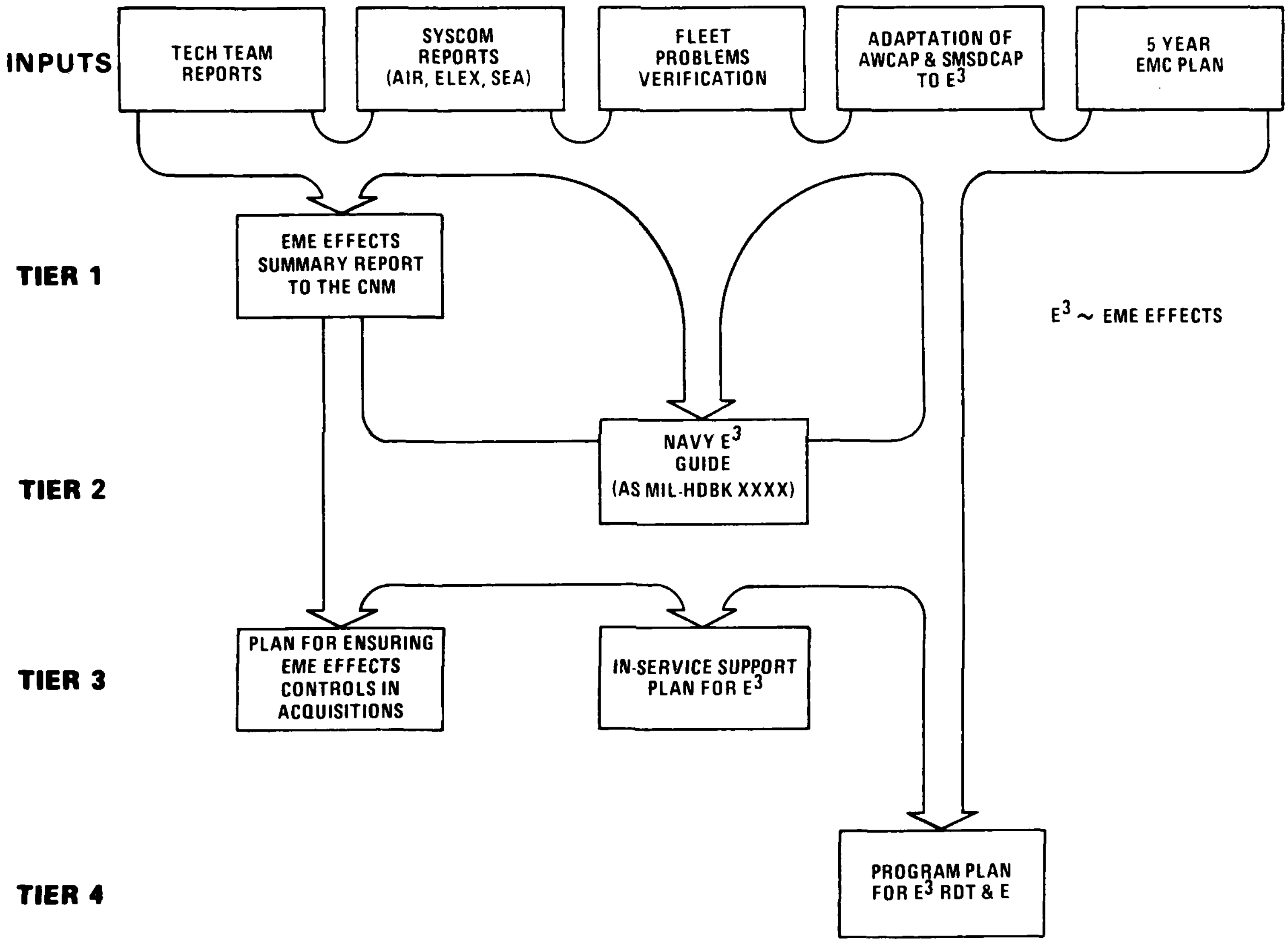

FIGURE 4-1. TESSAC DOCUMENTS RELATIONSHIPS

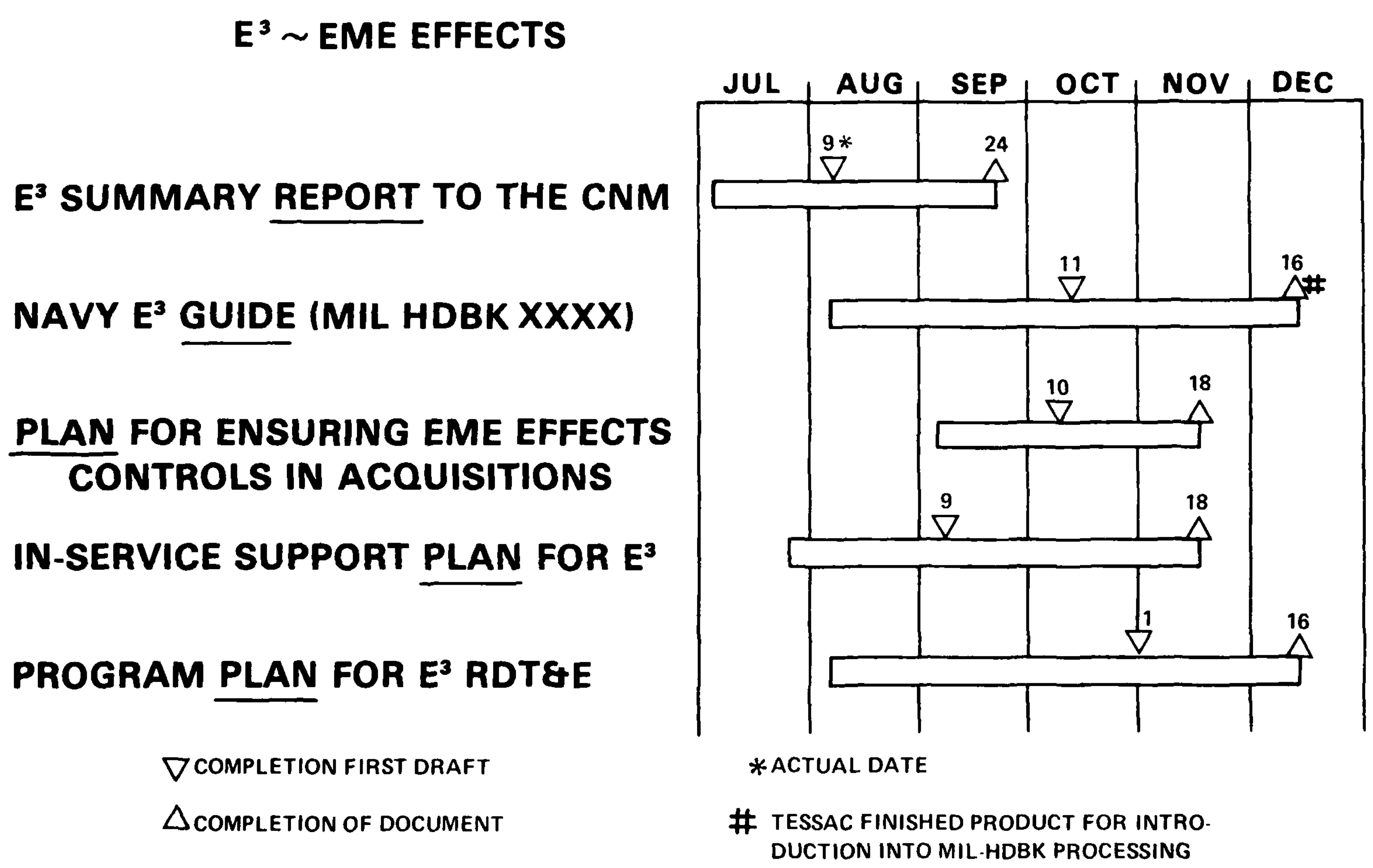

FIGURE 4-2. MASTER DOCUMENT SCHEDULE

4.3 Plan for Ensuring EME Effects Controls In Acquisitions

This plan will be the vehicle to develop and implement a recommended management for the acquisition, deployment and support of platforms, systems and equipment, and propose the means for its implementation. The plan will include recommended policies and procedure overviews covering requirements for resources, contractual documents and their review, management control and review, and test and evaluation requirements. This plan will discuss procurement planning documentation requirements and the division of responsibilities and functions of Program/Project Managers, Acquisition Managers, and reviewing/approving echelons. Recommended changes to existing instructions and directives, required for consistency and to ensure that requirements will be fulfilled, will be coordinated with the concerned SYSCOMs or other offices of origination and attached as appendices. This is envisaged as a one-time document, having served its purpose when its recommendations are implemented and the EME provisions are factored into pertinent documents and procedures.

This plan responds in part to paragraph 2.d of CNM's 12 April 1976 letter and is scheduled for publication in November 1977.

4.4 In-Service Support Plan for EME Effects

The In-Service Support Plan will develop a program of fleet EME support actions so designated and scheduled as to assure acceptable effectiveness of electronic/electrical systems and equipments during the in-service phase of their life cycle. The proposed actions would implement a technical-management closed-loop system whereby EM incidents would be observed, analyzed and resolved, and provide inputs for EME effects RDT&E. Emphasis will be placed upon the high-priority requirements for consolidating the best techniques for auditing and managing the EME effectiveness status of fleet forces. This plan may interact with other existing documents of specific programs, e.g., FEMR (Fleet EM Readiness), SEMCIP, and the NMC Five Year EMC Plan.

This plan responds in part to paragraph 2.d of CNM's 12 April 1976 letter. Publication is scheduled for November 1977.

4.5 Program Plan for EME Effects RDT&E

This plan will develop a comprehensive RDT&E program designed to provide the technical capabilities and tools to solve and in the future prevent or

reduce to acceptable levels the EM problems currently degrading fleet operations.

Deficiencies noted will be compared with on-going RDT&E tasks to determine possible additional EME Effects RDT&E needs. A program to achieve these needs will be included in the plan. This will be a continuing document with periodic review and revision, as judged appropriate. The plan will be coordinated with documents with which it interacts, and is intended to replace the NMC Five Year EMC Plan FY-78-FY-82.

This plan responds to paragraph 2.e of the CNM letter of 12 April 1976 and is scheduled for publication in December 1977.

5. CONCLUSIONS

5.1 General

The principal conclusions of the state-of-electromagnetic effects relative to system acquisition and in-service support are:

- o The State-of-EM technology within the Navy is marginally keeping pace with the state-of-the-art. This technology is adequate to prevent or reduce most of the Navy's EM problems. However, resources are fragmented throughout various activities and are unwieldy to coordinate.
- o The lack of supporting data bases are a major inhibition to EM technology development and application such that technology transfer to users is not being accomplished efficiently.
- o Technology is not being utilized in a timely and efficient manner during system conceptual, early development and design phases.
- o Technical capabilities to apply technology are not uniform in all EM disciplines at all levels from analysis and test tools through managerial application.
- o Specifications and standards lag technology and are not supportive of EM engineering efforts. Of all the CNM task areas studied, the specifications and standards area was most seriously faulted by Technical Teams. Both specifications and standards content and revision procedures are in need of improvement. Specifications and standards require tailoring to systems in order to be used most advantageously.
- o Interfaces between acquisition managers (PM/AMs), the Fleet and the EM engineering community are weak.
- o There are too few knowledgable personnel in the SYSCOMs charged with the responsibility for ensuring that EM is incorporated into system acquisition and in-service actions. Unless and until the strength and quality of line engineering manager support is increased to levels commensurate with the importance and priority of EM technology, current deficiencies will persist.

5.2 Deficiencies in Technology

- o The technology base is sufficiently developed to design deficiency-free equipment and to correct existing deficiencies in EMC.

5.3 Deficiencies in Capabilities

The EM analysis capability lags testing capability--testing being used as a substitute for analysis. Specific deficiencies in EM analysis include:

- o Gaps in threat definition and analysis.
- o Limited modeling/prediction models and validation criteria for computer codes/programs now in use.
- o Performance prediction testing, and platform placement has been limited to component/equipment/simple systems, single small platforms and non-sophisticated environments.
- o System level analysis and testing is limited or [illegible] ible for complex systems, multiple systems, large structures and complex env[illegible]onments, except by employing wide parameter margins. (Existing analysis and test facilities and designed for missiles and aircraft rather than ships.)
- o Instrumentation is needed to accommodate newest technologies.
- o Manpower and facilities allocated to the EM community are insufficient for the responsibilities and workload now carried. The Navy's pool of experienced EM personnel is sparse and additional resources will have to be developed or sought in industry to complement the Navy's capabilities.
- o Within the fleet, many EM problems are not properly identified and reported as such, resulting in improper application of EM engineering to resolve fleet EMI problems.
- o There are limited programs for reporting fleet EMI problems (excepting SEMCIP for ships problems) and only insufficient and non-systematic methods for correcting such deficiencies.
- o There are limited fleet EMC training programs for EM maintenance procedures, on-site instructions/aids, information exchange and feedback.

5.4 Deficiencies in Specifications and Standards

Existing military specifications and standards do not satisfy the need for specific, current, yet feasible, requirements and controls, nor do they effectively capitalize upon the EM state of technology. With few exceptions, they are reported to be overlapping, contradictory, out-dated, impractical to implement and lacking in pertinent EM provisions.

o Specifications and standards in current use are unanimously cited by the Technical Teams as an area of multiple deficiencies, which they documented, discipline by discipline, item by item. The sole exceptions are specifications and standards relating to HERO (Hazards of Electromagnetic Radiation to Ordnance), HERF (Hazards of Electromagnetic Radiation to Fuel) and perhaps HERP (Hazards of Electromagnetic Radiation to Personnel).

o There are no specifications and standards which explicitly call out ECCM, EMP, or EMV requirements.

o There are no specifications and standards to cover advanced technology (e.g., fiber optics, composite materials), large platform test procedures, hull penetration, and various other ship and aircraft requirements.

o Handbooks are of limited aid to EME engineers; however, their deficiencies do far less harm than do those of specifications and standards.

o There are indications that parts of the general specifications and standards have been derived from basic OPNAV and supportive NAVMAT documentation (such as OR's, DP's) which in turn lack specific EM parameters in defining and identifying specifications and standards in equipment/systems or platform procurement contracts.

o A long time lag between technological development and publication of military specifications and standards is endemic to the DoD standardization system.

o Procurement specifications and standards properly prepared and applied can avoid many expensive engineering modifications and delays in system/platform acceptance as well as periods of unreliable operation and costly retrofits.

o Tailoring of procurement specifications and standards is a viable compromise between rigid, detailed guidelines (prone to become obsolete quickly) and expensive custom-built designs. Coordinated tailoring likewise conserves engineering personnel and facilitates realistic trade-offs.

6. RECOMMENDATIONS

The recommendations as set forth below are derived from the conclusions presented in the preceding section. Amplifying plans for their implementation will be provided in the TESS Action Council documents under development separately.

Recommendations are as follow:

The Chief of Naval Material

o Take actions, through regular reviews of formal planning documents, to ensure that policies for inclusion of EM requirements throughout equipment life cycles are complied with. (To be addressed in the Plan for Ensuring EME Effects Controls in Acquisitions).

o Ensure that adequate funding is provided for EM technology development and technology management, in RDT&E funding planning and allocation. (To be addressed in the Program Plan for EME Effects RDT&E).

o Cause allocation of engineering personnel to staff additional NAVMAT/SYSCOM/field activity EM billets sufficient for recommended additional emphasis.

o Ensure through routine review, that EM requirements are contained in development proposals, and elsewhere in conceptual phases of acquisition. (To be addressed in Plan for Ensuring EME Effects Controls in Acquisitions).

The Commanders, Systems Commands

o Establish and support EM organizations adequate to perform necessary EM functions effectively on a continuing basis.

o Develop procedures for graduated levels and types of EM engineering assistance to acquisition managers ensuring early and continuing participation throughout acquisition. (To be addressed in the Plan for Ensuring EME EFFECTS Controls in Acquisitions).

o Expand EMCAB concept to include engineering personnel in all EM disciplines, supporting acquisitions managers from system conceptual phase through acquisition.

o Increase scope of training programs to integrate all EM disciplines with particular emphasis on on-the-job fleet training in EM maintenance procedures. (To be addressed in the In-Service Support Plan for EME Effects).

o Issue or modify directives to implement and enforce CNM policies on EME. (To be addressed in the Plan for Ensuring EME Effects Controls in Acquisitions).

o Define EM requirements for ship, aircraft and missile technical characteristics down to appropriate levels of detail.

o Initiate collection, maintenance and retrieval of EM data in compatible format on current basis for easy access by potential users.

o Initiate early review of EM-related military specifications, standards and handbooks; bring current with technology, and expand for broad life cycle application.

o Develop and issue tailoring procedures and guidance for preparation of procurement specifications complementing military specifications and standards.

o Develop specifications and standards in the areas of new technology (composites, phased arrays and digital processors) and EM disciplines (EMV, EMP), not now included.

o Ensure that RDT&E programs provide the EM technology and facilities required to support SYSCOM material development and Fleet support programs.

o Implement program similar to SEMCIP for ships to identify and correct airborne weapons systems in-service EM problems, obtaining sponsorship support in OPNAV.

o Modify existing reporting and management information systems to categorize and report fleet EM problems and improve dissemination of information. (To be addressed in the In-Service Support Plan for EME Effects).

o Develop system level acceptance testing capability.

The Chief of Naval Material Recommend to the Chief of Naval Operations that He

o Ensure by appropriate review that EM requirements are incorporated into the Mission Element Needs Statements, Operational Requirements and Naval Decision Coordination Papers.

APPENDIX A

GLOSSARY

AM - Acquisition Manager

AP - Acquisition Process

ASPR - Armed Service Procurement Regulation

AWCAP - Airborne Weapons Corrective Action Program

BIS - Bureau of Inspection & Survey

BUMED - Bureau of Medicine

CCM - Counter-Counter Measures

DCAP - Deficiency Corrective Action Program

DCP - Decision Coordinating Paper

DNA - Defense Nuclear Agency

DNI - Director of Naval Intelligence

DP - Development Proposal

ECAC - Electromagnetic Compatibility Analysis Center

ECCM - Electronic Counter-Counter Measures

ECM - Electronic Counter Measures

E^3 - Electromagnetic Environment Effects

EF - Electrostatic Field

EM - Electromagnetic

EMC - Electromagnetic Compatibility

EMCAB - Electromagnetic Compatibilty Advisory Board

EMCPP - Electromagnetic Compatibility Program Plan

EME - Electromagnetic Environment

EMI - Electromagnetic Interference

EMP - Electromagnetic Pulse

EM-Power - Electromagnetic Power

EMPRESS - EMP Radiation Environment Simulator for Ships

EMPSAC - EMP Simulator for Aircraft

GLOSSARY (Continued)

EM-Safety - Electromagnetic Safety

EMV - Electromagnetic Vulnerability

E-O - Electro-Optics

ESM - Electronic Warfare Support Measures

EW - Electronic Warfare

FEMR - Fleet Electromagnetic Readiness

GSE - Ground Support Equipment

HERF - Hazards of Electromagnetic Radiation to Fuels

HERO - Hazards of Electromagnetic Radiation to Ordnance

HERP - Hazards of Electromagnetic Radiation to Personnel

IEEE - Institute of Electrical/Electronic Engineers

IEMCAP - Intrasystem Electromagnetic Compatibility Analysis Program

IMI - Intermodulation Interference

MAPPS - Modeling and Analysis of Power Processing Systems

MENS - Mission Essential Needs Statement

NDCP - Navy Decision Coordinating Paper

OPEVAL - Operational Evaluation

OPTEVFOR - Operational Test and Evaluation Force

OR - Operational Requirement

OTD - Office of Test Direction

PM - Project/Program Manager

POA&M - Plan of Action & Milestones

P-Static - Precipitation Static (Triboelectricity)

RADHAZ - Radiation Hazards

RDT&E - Research, Development, Test & Evaluation

REWSON - Reconnaissance, Electronic Warfare and Naval Intelligence Processing Systems

RIMPAC - Pacific Fleet Surface-to-Air Missile Exercise

SAE - Society of Automotive Engineers

SEMCA - Shipboard Electromagnetic Compatibility Analysis

SEMCAP - System Electromagnetic Compatibility Analysis Program

GLOSSARY (Continued)

SEMCIP - Shipboard Electromagnetic Compatibility Improvement Program

SEMI - Special Electromagnetic Interference

SHIPALT - Ship's Alteration

SOT - State of Technology

S/S - Specifications and Standards

TECHEVAL - Technical Evaluation

TECS - Tactical Electromagnetic Coordination and Support

TEMP - Tactical Electromagnetic Programs also;

TEMP - Test and Evaluation Mast Plan

TESSAC - Tactical Electromagnetic Systems Study Action Council

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DATE
ILME